Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	CONTROL SYSTEM THEORY
COURSE CODE	:	BEH 30603
PROGRAMME	:	BACHELOR OF ELECTRONIC ENGINEERING WITH HONOURS
EXAMINATION DATE	:	JUNE 2015/JULY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 The pitch control loop for a ship is shown in **Figure Q1**. Let K_2=1.

(a) Select the value of K_1 that ensures that the closed-loop pitch control system is critically stable.

(12 marks)

(b) Based on the characteristic equation of the system and K_1 obtained in (a), write matlab codes to find the roots of the closed-loop system.

(4 marks)

(c) Determine the steady state error of the closed-loop system for a step input. Assume K_1=1.

(4 marks)

Q2 (a) State the five rules to sketch a root locus.

(5marks)

(b) Consider the system shown in **Figure Q2(b)**.

(i) Sketch the root locus of the system.

(6 marks)

(ii) Find the departure angle.

(3 marks)

(iii) Find the range of K for the system to be stable.

(3 marks)

(iv) Choose the value of K when the system is critically stable.

(1 marks)

(v) Find the closed-loop poles for the value of K in (iv)

(2 marks)

Q3 Consider the unity feedback control system as shown in **Figure Q3**.

(a) Draw the Bode log-magnitude and phase plots of the forward transfer function. *Hint:* $\zeta=0.2$

(14 marks)

(b) If K=100, find the system's :

(i) Bandwith

(2 marks)

(ii) Phase margin

(2 marks)

(iii) Gain margin

(2 marks)

Q4 (a) Explain the purpose of

(i) Phase-lag compensator

(2 marks)

(ii) Phase-lead compensator

(2 marks)

(b) A unity feedback open-loop transfer function of a control system is given by

$$G(s) = \frac{12}{s(s+3)}$$

Design a phase-lead compensator that gives $\omega_n = 5$ rad/sec and ζ=0.4.

(16 marks)

Q5 Design a phase variable feedback gains to yield 5% overshoot and a peak time of 0.3 seconds for a plant represented in the state space below:

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -36 & -15 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 100 & 100 & 0 \end{bmatrix} x$$

(20 marks)

-END OF QUESTION –

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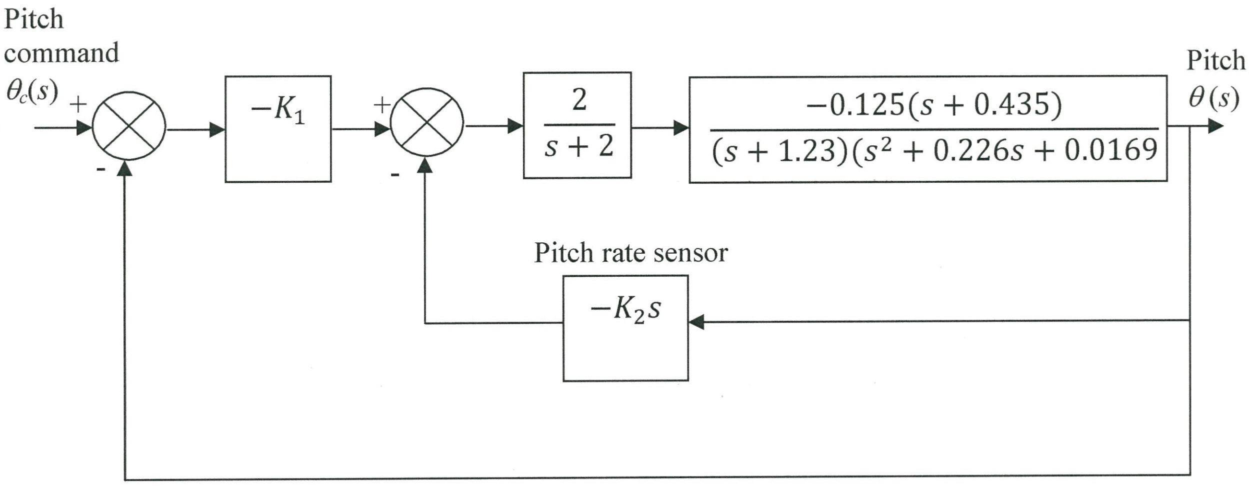

FIGURE Q1

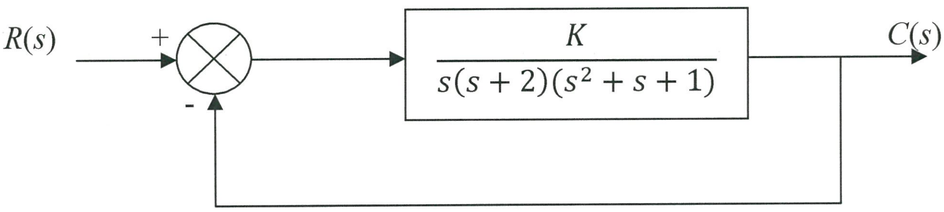

FIGURE Q2(b)

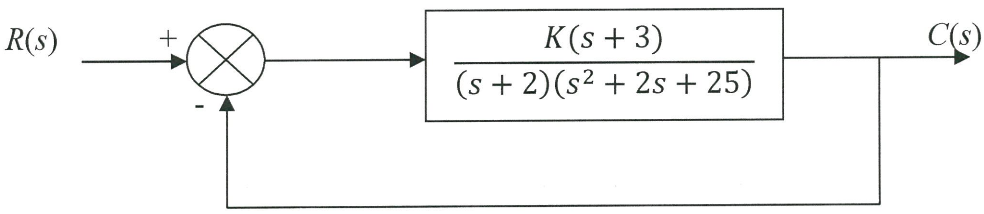

FIGURE Q3

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TABLE 1
Laplace transform table.

f(t)	*F(s)*
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
$tu(t)$	$\frac{1}{s^2}$
$t^n u(t)$	$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$	$\frac{1}{s+a}$
$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$

TABLE 2
Laplace transform theorems.

Name	Theorem
Frequency shift	$\mathscr{L}\left[e^{-at}f(t)\right]=F(s+a)$
Time shift	$\mathscr{L}\left[f(t-T)\right]=e^{-sT}F(s)$
Differentiation	$\mathscr{L}\left[\frac{d^n f}{dt^n}\right]=s^n F(s)-\sum_{k=1}^{n} s^{n-k} f^{k-1}(0^-)$
Integration	$\mathscr{L}\left[\int_{0^-}^{t} f(\tau)d\tau\right]=\frac{F(s)}{s}$
Initial value	$\lim_{t\to 0} f(t)=\lim_{s\to\infty} sF(s)$
Final value	$\lim_{t\to\infty} f(t)=\lim_{s\to 0} sF(s)$

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TABLE 3

2nd order prototype system equation.

$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$	$T_r = \frac{\pi - \cos^{-1}\zeta}{\omega_n\sqrt{1-\zeta^2}}$
$\mu_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$	$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$
$T_s = \frac{4}{\zeta\omega_n}$ (2% criterion)	$T_s = \frac{3}{\zeta\omega_n}$ (5% criterion)